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Method for energy management of air-conditioning units

The invention relates to a method for energy management of air-conditioning units, in particular air-conditioning units having a plurality of air-conditioning compressors.

In passenger cars and trucks having an internal combustion engine or electric drive and a plurality of air-conditioning units, either one or more air-conditioning compressors are used to produce cold air for each cooling circuit. The air-conditioning compressors are actuated immediately by the starting of the internal combustion engine. This results in the internal combustion engine or electric drive being loaded very heavily by the starting up of the air-conditioning compressors and almost stalling.

DE 199 60 079 A1 discloses a method for switching various classes of loads on and off by means of switching elements within the scope of an energy management operation which is carried out by a control device, in particular in a motor vehicle. The various classes of loads have various priorities but it is possible to adapt the prioritization of the loads during ongoing operation, said adaptation also taking into account the perceptibility of the operating states caused by a switching over operation. In this conventional method, for example the air-conditioning compressor or compressors are switched off in the acceleration phase as loads with the lowest priority, in order to prevent the braking effect. When there is a change in state, the individual load cannot be transferred to a class with a lower priority than the class in which it is in the normal state, i.e. when sufficient supply of energy is ensured in the usual travel mode. The switching takes place in such a way that individual loads of one class are switched, and the switching either takes place successively, with adaptation to the load state, or in parallel if a plurality of loads have to be switched for compensation purposes, or the entire class if necessary.

However, this energy management is carried out with dynamic adaptation of the priorities of individual loads only during operation. There is no indication whatsoever that when at least one previously deactivated load is started or restarted particular problems occur as a result of the starting up loading by loads, for example when air-conditioning compressors startup and restartup, or how these problems could be solved.

The object of the present invention is therefore to configure a method for energy management of air-conditioning units which considerably reduces the loading on the internal combustion engine or electric drive when the air-conditioning compressors start up, prevents stalling and makes subsequent adjustment by the engine electronics as comfortable as possible.

This object is achieved according to the invention by means of a method for energy management in air-conditioning units having the features of claim 1. Advantageous developments of the invention are specified in the subclaims.

As a result of the method according to the invention for energy management of air-conditioning units, better compensation of the idling stability of an internal combustion engine or drive takes place. The engine/drive operates in a more stable fashion. Fluctuations in rotational speed or switch-on judder when switching on coolant compressors are minimized. This allows the comfort for the customer to be increased.

This and further objects, features and advantages of the present invention become apparent from the following description of a preferred exemplary embodiment of the invention in conjunction with the drawing, in which:

Fig. 1 with Figs 1A to 1D shows a flowchart of a method according to the invention for energy management of air-conditioning units,

Fig. 2 shows an exemplary signal profile for the switching on of an air-conditioning compressor,

Fig. 3 shows an exemplary signal profile for the switching off of an air-conditioning compressor, and

Fig. 4 with figures 4a and 4b shows exemplary profiles of a factor for reducing the power of the air-conditioning compressor.

The inventive method for energy management of air-conditioning units will be described below with reference to Fig. 1 which is divided into Fig. 1A to 1D for the sake of clarity.

In the inventive method for energy management of air-conditioning units, after the start in a step S1 definitions are made as to which coolant compressor has a high priority and which has a subordinate priority. For example, the air-conditioning compressor which is assigned to a front vehicle region is allocated a higher priority than the air-conditioning compressor which is assigned to a vehicle region so that after a start moisture is firstly removed from the sucked-in air so that the front windscreen is prevented from misting up.

Then, in a second step S2 with the substeps S2a, S2b and S2c it is interrogated whether a vehicle engine is started, the engine is in the idling mode or the engine or vehicle drive is in the full load mode and an acceleration bit by which the air-conditioning compressor has previously been switched off is set.

If one of these conditions interrogated in steps S2a, S2b and S2c is fulfilled, the energy management according to the invention is carried out (steps S4 to S20). If none of the conditions interrogated in steps S2a to S2c is fulfilled, a conventional regulating process of the air-conditioning unit is carried out (step S3).

The regulating sequences which respectively follow the interrogations in steps 2a to 2c will be explained in detail below.

If it is detected in step S2a that the engine has been restarted, in a step S4 the air-conditioning compressor which is assigned to the front vehicle region, i.e. the air-conditioning compressor with the highest priority, is firstly actuated so that the front vehicle region conditions air as quickly as possible after the engine starts, i.e. removes the moisture from the sucked-in air, and misting up of the front windscreen is avoided. Then, in step S5 the air-conditioning compressor which is assigned to the rear vehicle region, i.e. the air-conditioning compressor with a lower priority, is actuated after a predefined time T. The predefined time T is here a time which is predefined by a design or size of the air-conditioning compressor or ambient temperature or a coolant pressure of, for example, 10 to 48 Nm which is necessary for the engine to compensate for the load which is added to the internal combustion engine/motor vehicle drive by the air-conditioning compressor. This predefined time T may be, for example, approximately 3 seconds.

However, if the result in step S2a is that restarting of the engine has not occurred, the sequence continues to step S2b in which it is checked whether the engine is in the idling mode.

If it is detected in step S2b that the engine is in the idling mode, it is checked whether an air-conditioning unit request signal is present (step S6). If the air-conditioning unit request signal is present in step S6, an air-conditioning compressor actuating signal Komp_Stell and an anticipated air-conditioning compressor torque M_KOMP are simultaneously output to an engine control device on, for example, a CAN (step S7). In response to this air-conditioning compressor torque M_KOMP, the engine control device calculates, in step S8, a load increase signal L as a function of the air-conditioning compressor torque M_KOMP and outputs it to the engine after a predetermined time T3. A compressor flow which corresponds to the load increase signal L calculated in step S8 is output in step S9 with a switch-on delay time T1 by the engine to the air-conditioning compressor. In Figs 2 and 3, KOMP_EIN designates a compressor switch-on signal.

During the switch-on delay time T1, it is checked, in step S10, whether a deactivating switch, for example a manual switch, for deactivation of the air-conditioning unit has been operated. If the result of this checking in step S10 reveals that a deactivating switch has been operated, all the air-conditioning compressors of the associated cooling circuit are switched off. Then the system returns to step S2a. If the result in step S10 is that the deactivating switch has not been operated, it is checked whether an air-conditioning compressor with a lower priority is present. If that is the case, the system returns to step S7 with a time delay T. If not, the system returns to step S2a.

Then, after the predefined time T has expired the regulating process is carried out according to steps S6 to S10 for the air-conditioning compressor with the next lowest priority.

It is to be noted that if the air-conditioning compressors are switched off there is no need to differentiate between the different priorities but instead all the air-conditioning compressors can be switched off simultaneously, i.e. without the chronological offset, and without complying with the predefined time T.

Exemplary signal profiles for the switching on and switching off of an air-conditioning compressor are shown in figures 2 and 3.

However, if the result in step S2b is that the engine is not in the idling mode, the sequence continues to step S2c. In step S2c it is checked whether an acceleration bit is set on the CAN bus. The setting of the acceleration bit is equivalent to a reduction in power of the air-conditioning compressor as a function of the external temperature, i.e. the power of the air-conditioning compressor is reduced at maximum for a predetermined time T4.

Figure 4 with figures 4a and 4b shows the profile of a factor for reducing the power of the air-conditioning compressor if the acceleration bit is present at least for the time period T4 and T4*, depending on whether or not the external temperature is above or below a threshold value tA*th. For example, T4 may be 8 seconds in the case of an external temperature above a threshold value tA*th of, for example 25°C, while T4* is 5 seconds below the threshold value tA*th. If the acceleration bit is reset before the expiry of the time period T4 or T4*, the speeding up of the air-conditioning compressor takes place immediately with the gradient shown in figure 4 with figures 4a and 4b, depending on which external temperature tA* is

present. Before the power can be switched off again or reduced, the air-conditioning compressor must have been switched on for at least a time period T5, with T5 being significantly longer than T4. T5 may be 20 seconds, for example.

After the step S2c, in a step S14 the external temperature tA* is determined and the sequence is continued to a step S15. In step S15 it is decided whether the external temperature tA* is above a predetermined threshold value tA*th. If it is above the threshold value tA*th, in step S16 the air-conditioning compressor is switched off over a time period T4, as shown in figure 4a, and otherwise it is switched off over a time period T4* (step S17). During the time period T4 or T4*, monitoring is carried out in step S16a or S17a to determine whether the acceleration bit is still set. If the acceleration bit is no longer set in step S16a or S17a, the air-conditioning compressor is speeded up immediately in step S18, with the gradient determined from figure 4a or 4b. If the acceleration bit is still set in step S16a or S17a, the deactivation is ended after the time period T4 or T4* in step S19 or S20 and the air-conditioning compressor is powered up again with the gradient shown in Figs 4a and 4b.

The steps S2c, S14 to S20 are repeated for the air-conditioning compressor with the next lowest priority.

It is to be noted that the steps S2a to S2c can also be carried out in a changed sequence or simultaneously without departing from the basic idea of the invention.

In this way it is possible, by means of the inventive method for energy management of air-conditioning units in motor vehicles, to avoid switch-on judder or near stalling of the engine of the motor vehicle owing to the simultaneous switching on of a plurality of air-conditioning compressors.

To summarize, the present invention discloses a method for energy management of air-conditioning units in motor vehicles, in particular air-conditioning units having a plurality of air-conditioning compressors. The method according to the invention prevents very heavy loading of an engine of a motor vehicle and prevents the engine almost stalling when the air-conditioning compressors start up, as currently occurs during starting of the engine of the motor vehicle, after idling of the engine of the motor vehicle as well as after an acceleration process in which the engine was in the full load mode. For this purpose, each of the air-conditioning compressors is allocated a different priority, for example the highest priority is assigned to the air-conditioning compressor for a front vehicle region which is intended, inter alia, to prevent the front windscreen misting up by removing moisture from the air, and a lower priority to the air-conditioning compressor for a rear vehicle region. If one of the states specified above is detected during a state interrogation, the air-conditioning compressors are each switched on successively delayed by a predetermined switch-on delay time in accordance with this allocated priority in response to request signals. In contrast, deactivation can take place simultaneously.